Investigating the Effect of Superpower Priming and Representation on Virtual Reality Interaction

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ABSTRACT

We investigate superpowers as a way to both present and visually represent interaction techniques in VR. A mixed-design study (n=20) compares variants of the well-known Go-Go interaction technique in a non-game selection task. The primary factors are the effect of using superhero-themed priming (including a brief backstory intervention and a modified avatar appearance), and modifying the visual representation of the interaction technique to be reminiscent of superhero powers.

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1 INTRODUCTION

In fiction, superheroes like Superman have superpowers that go beyond what is possible in reality. Similarly, many input techniques in virtual reality (VR) can be represented as beyond-real; for example, Go-Go [5] and Worlds-in-Miniature [6]. We explore how giving a superhero-inspired context to a VR interaction technique might make it easier to use and more enjoyable.

We conduct a mixed-design, remote study investigating both the effects of *priming* (between-subjects) and *representation* (within-subjects) on a target selection task using Go-Go. We use *priming* to refer to presenting something that leads to activation of associated items in memory [4], specifically, to describe the combination of backstory and avatar. We chose Go-Go because it is one of the most highly-cited VR interaction techniques and is applicable in many different kinds of tasks. Similarly, we chose a target selection task because it is a basic form of interaction and has the potential to generalize to many VR contexts.

2 EXPERIMENT

We recruited 20 right-handed participants (age 19–34; 13 male; 7 female), each received a $15 gift card. All but 2 had experience with VR and used a variety of systems. They downloaded a Unity program for Windows and SteamVR and ran it on their own system.

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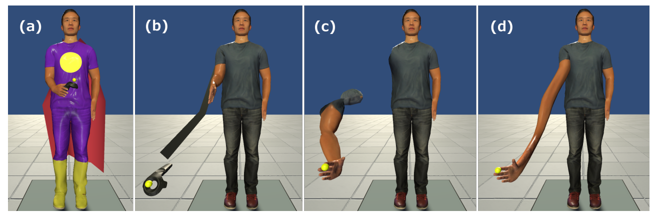

Figure 1: Examples of *priming* and *visual representation* conditions: (a) SUPERPOWER and OFF; (b) NEUTRAL and LINE; (c) NEUTRAL and DISLOCATE; (d) NEUTRAL and STRETCH.

Task and Procedure. After watching a 2-minute explanatory video, the participant ran the experiment (30–45 minutes). In VR, they first calibrated their height and relative target positioning by holding the right controller near their stomach, looking forward, and pressing a button. There were 2 between-subject conditions. For NEUTRAL PRIMING, participants were told: "You will be selecting targets" and a fixed generic male avatar was used (Figure 1b–d). For SUPERPOWER PRIMING, participants were told: "You have the superpower of being able to reach far distances. You will be using this superpower to select targets" and their avatar was dressed in a superhero-like costume with a cape (Figure 1a). At one side, there was a full-height virtual mirror so the participant could see their avatar. Instructions were provided as audio and text on an in-scene billboard.

Regardless of condition, the task was to select a "start" target and then an "end" target quickly and accurately. The turquoise start target was positioned 30 cm in front of the calibrated stomach position. The red end target was at one of 3 depths planes, 0.5, 1.0, or 1.5 m in front of the calibrated stomach position, positioned within a plane either 0.5 m up, down, left, or right from the centre. All targets were 15 cm diameter spheres. A correct selection highlighted the target and played a "click" sound, otherwise a "beep" signalled an error and that selection was repeated until successful. All 12 end target positions were presented in a random, non-repeating order as one block. 6 blocks of tasks were completed for each of 4 pointing technique visual representation conditions:

Detachable arms (DISLOCATE): The entire arm dislocates at the shoulder when the amplified controller position is beyond reach. The hand is where the controller would be. The controller is not shown (Figure 1c; inspired by Arm-Fall-Off-Boy from *Zero Hour*).

Elastic arms (STRETCH): The arm stretches arbitrarily long. The hand is where the controller would be. The controller is not shown (Figure 1d; inspired by Mister Fantastic from *The Fantastic Four*). To improve realism, we use inverse kinematics to maintain the same elbow angle as if the arm were not elongated.

Controller only (OFF): The arm matches the real arm position, and the virtual controller flies out of the hand (Figure 1a). The controller model is matched to the participant's physical controller. This serves as a baseline for *detachable arms* and is most similar to the original Go-Go technique.

Controller with line (LINE): Same as *controller only*, but a thick black line is drawn between the shoulder and the virtual controller (Figure 1b). This serves as a baseline for *elastic arms*. The line segment bends using the same approach as *elastic arms*.

For consistency, all representations used a 3 cm yellow sphere as a "cursor". It rendered slightly beyond the controller tip or at the tip of the avatar's index finger, as applicable.

Design. There are 2 independent variables: PRIMING was between-subjects with levels {NEUTRAL, SUPERPOWER} and REPRESENTATION was within-subjects with levels {OFF, LINE, DISLOCATE, STRETCH}. Each REPRESENTATION had 6 BLOCKS. REPRESENTATION was balanced with a Latin square and PRIMING was assigned to participants randomly with a balanced number.

Two measures were computed from logs: *Selection Time* from selecting the start target until successfully selecting the end target (not reset if end target misses); and *Error Distance*, the distance from the "cursor" to the end target centre on the *first* selection attempt.

A questionnaire after each condition included the NASA TLX, Self-Assessment Manikin (SAM) [1] *valence* and *arousal* scales, and the 10-item revised HEMA scale [3] to assess hedonic and eudaimonic motives. We also included the first 3 body ownership questions from [2]. We replaced "hand" with "arm" and used a 7-point Likert-type scale. Upon completion of all conditions, participants were asked the open-response questions "How did you find the task in each [representation] in VR?" and "How did you feel during each of the different [representations] in VR?".

2.1 Summary of Key Results

2.1.1 Quantitative Measures. For each combination of participant, PRIMING, and REPRESENTATION, trials longer than 3σ from the mean were excluded as outliers (1.2%). The first block was removed as practice. 3 participants (2 NEUTRAL, 1 SUPERPOWER) were removed from the performance analysis due to abnormally high error rates (more than 1.5× the IQR above the upper quartile). Statistical analyses used Holm-Bonferonni corrected p-values. For performance measures (*Selection Time* and *Error Distance*), A PRIMING × REPRESENTATION × BLOCK mixed factorial ANOVA was used with post hoc t-tests, with log-transformed *Selection Time* to correct for normality. We used Mann-Whitney U tests for PRIMING and Friedman tests with post hoc Wilcoxon signed-rank tests for REPRESENTATION. We found no significant effect of PRIMING or REPRESENTATION on performance measures. Based on HEMA scores, compared to NEUTRAL PRIMING, SUPERPOWER PRIMING was more motivated by fun (median 6.0 vs. 5.0), pleasure (median 6.0 vs. 4.5), relaxation (median 5.0 vs. 3.0), pursuit of excellence (median 7.0 vs. 5.0), and using the best in oneself (median 7.0 vs. 5.0; all $p < .05$). Compared to NEUTRAL PRIMING, SUPERPOWER participants with felt more strongly that the virtual arm was their own ($p < 0.01$, median 5.0 vs. 2.0), but experienced a marginally lower feeling of control ($p < .05$, medians both 6.0, mean 5.7 vs. 6.1). NASA TLX frustration was slightly higher for SUPERPOWER PRIMING than NEUTRAL ($p < .05$, median 9.0 vs. 6.0).

2.1.2 Follow-up Question Responses. 5 participants preferred the superpower representations (STRETCH and DISLOCATE). STRETCH was called "fun" (P7, P11) and "super cool" (P7). LINE was called "confus[ing]" (P15) and "redundant" (P1). In contrast, 8 participants preferred OFF or LINE. DISLOCATE was felt to be "like a clunky cursor" (P5) and "the least like a physical arm" (P8).

5 participants felt the superpower representations were easier to control. For DISLOCATE, P10 said this was because they could see "end-to-end of the Arm". P1 and P4 found it challenging to predict the controller position for OFF. In contrast, 4 participants found the non-superpower representations easier. P2 felt the dislocated arm was too big and P17 said, "it didn't feel like [...] an arm". For STRETCH, P9 felt their physical controller conflicted with the avatar's hand. 3 participants found LINE or STRETCH easier to control than OFF or DISLOCATE because they helped measure distances, whereas 4 participants felt the opposite, for reasons such as occlusion.

7 participants found one or more of the superpower representations to be uncanny. For example, "If VR graphics was anything real [...] I might have had a mini heart attack" (P4, DISLOCATE); "Some of the arms kind of freaked me out" (P16); and STRETCH "made me feel nauseas [sic.] because it was just too life-like" (P17). The participants who felt the superpower representations were uncanny were mutually exclusive from the 5 who preferred them.

2 participants in the NEUTRAL priming condition explicitly related STRETCH to Mister Fantastic from the *Fantastic Four*, making the connection to superheroes entirely on their own.

3 CONCLUSION AND FUTURE WORK

Further research is needed to understand the effects of priming and visual representations on more complex interaction techniques. To keep the experiment short and ease remote deployment, we used the same virtual avatar across all participants. Participants may feel misrepresented by the selected avatar, and for reasons such as the Proteus Effect, this could impact results. In follow-up work, we intend to run a larger-scale version of the experiment with additional interaction techniques, more participants, and the ability for participants to customize their avatars to look like themselves.

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